ZooKeys 31: 133–148 (2009)
doi: 10.3897/zookeys.31.123
www.pensoftonline.net/zookeys

RESEARCH ARTICLE

A peer-reviewed open-access journal
ZooKeys
Launched to accelerate biodiversity research

Review of the biodiversity and zoogeographical patterns of the weevils (Coleoptera, Curculionoidea) in Israel

Ariel-Leib-Leonid Friedman

Department of Zoology, The George S. Wise Faculty of Life Sciences, Tel Aviv University, Tel Aviv 69978, Israel

Corresponding author: *Ariel-Leib-Leonid Friedman* (laibale@post.tau.ac.il)

Academic editors: *E. Neubert, S. Taiti* | Received 8 March 2009 | Accepted 7 August 2009 | Published 28 December 2009

Citation: Friedman A-L-L (2009) Review of the biodiversity and zoogeographical patterns of the weevils (Coleoptera, Curculionoidea) in Israel. In: Neubert E, Amr Z, Taiti S, Gümüs B (Eds) Animal Biodiversity in the Middle East. Proceedings of the First Middle Eastern Biodiversity Congress, Aqaba, Jordan, 20–23 October 2008. ZooKeys 31: 133–148. doi: 10.3897/zookeys.31.123

Abstract

The rich but poorly studied weevil (Curculionoidea) fauna in Israel is briefly reviewed, highlighting the uniqueness of its high biodiversity and zoogeographical pattern. The collection efforts of about 100 years are briefly summarized. Ten families of weevils, comprising around 1.000 species, are recorded; the Nemonychidae are recorded for the first time.

Keywords

Curculionoidea, weevils, Israel, Middle East, biodiversity, zoogeography

Introduction

The Curculionoidea, or weevils, comprise the largest group of beetles with 62.000 described species, and the number of undescribed species is probably 3.5 times greater (Oberprieler et al. 2007). The weevils are extremely diverse morphologically, defying even the broad diagnoses offered for them. Common to all weevils is the forepart of their head, which is somewhat prolonged to extremely long, producing the so-called "rostrum", although in some groups the rostrum is almost entirely reduced. In these latter cases, the beetles can still be recognized as weevils by having one gular suture; by the labrum either absent or fused to the head; and by having five tarsomeres, of which

the 4th is strongly reduced and usually not visible. Some weevil families have geniculated antenna, whereas others have straight antenna. The 2–3 distal antennomeres are usually enlarged to form a distinct club, but this does not apply to all weevils. Although body pubescence comprised of variously shaped scales is very characteristic of weevils, there are also groups of species that are entirely bare. Most weevils are strict herbivores: the majority are associated with the vegetative or reproductive parts of plants, but certain groups are xylophages, mycetophages or detritophages (feeding on plant remnants). Weevils are distributed worldwide, with the exception of the Antarctic. Many weevil species are known as agricultural and stored-food pests. Weevils are subdivided into several families, the most recent subdivision system being that of Alonso-Zarazaga and Lyal (1999, 2002) and Lyal and Alonso-Zarazaga (2006), according to which weevils are subdivided into18 recent and four extinct families (if the Scolytinae are considered a subfamily within the Curculionidae). Fifteen families occur in the Palaearctic region, of these 11 are found in Israel (one is recorded here for the first time). The highly specific xylophagous Scolytinae (Curculionidae) and Platypodidae have been left out of this study.

Much of the world's weevil fauna still awaits study, although the fauna of the temperate parts of North America and Western Europe is relatively well known. Despite its closeness to Western Europe, the weevil fauna of the Middle East in general and of Israel in particular, has been insufficiently studied. Although the entomological research in the Middle East began as early as the time of Linnaeus (by his students Hasselquist and Forsskål), and many species and genera have been described from the area since then, not many attempts at a comprehensive study of the Middle Eastern weevil fauna have been made. Comprehensive faunistic works on weevils have been published to date only for Cyprus (Alziar 2007), Egypt (Alfieri 1976), Iran (Borumand 1998) and the United Arab Emirates (Magnano et al. 2009); the weevil fauna was partially surveyed for Jordan (Katbeh-Bader 2002), Iraq (Abdul Rassoul 1976, Al-Ali 1977, Derwesh 1965) and Kuwait (Al-Houty 1989, 2004) and large weevil taxa were surveyed for Jordan (Colonnelli 1987, Voss 1964), Saudi Arabia (Caldara 1993, Colonnelli 1984, Wanat 1990) and Yemen (Wanat 1990). No comprehensive works or even preliminary lists have been published recently on the weevil fauna of Bahrain, Lebanon, Syria, Oman and Qatar. The status of knowledge of the weevil fauna of Israel is somewhat intermediate, and demands intensive studies, due to the scarce knowledge on the one hand and to its diversity and uniqueness on the other hand.

The Israeli flora and fauna are extremely diverse relative to the country's small size and to other countries in the temperate zones. Several factors are probably responsible for this phenomenon: Israel is about 500 km long from north to south, and while its northern part has a mainly Mediterranean climate, its southern part is a desert. Consequently, temperatures are generally lower and rainfall is considerably higher in the north than in the south, and between these extremities the climate is highly variable. Although Israel's area covers only 27.799 m^2, the relief is very complex, and the country supports a great variety of biotopes: Mediterranean maquis and woodlands, deserts and semi-deserts, coastal and inland dunes, gorges and valleys, forest and tragacanth alpine scrublands. Altitudes range from 2.200 m above sea level (Mt. Hermon) to ~400 m below sea level (Dead Sea area).

Israel constitutes a zoogeographical crossroads between Europe, Asia and Africa, and its fauna is composed of elements originating from these continents. Nevertheless, Israel is located in the Palaearctic region, and Palaearctic elements dominate its fauna. Approximately one third of the animal species have a wide Palaearctic distribution (entire Palaearctic, Eurasian or West Palaearctic) (Furth 1975). The Mediterranean element is dominant in Israel's fauna, particularly north of Be`er Sheva' and as far east as the western edge of the Rift Valley. The southern and eastern parts of Israel are rich in desert (Saharo-Sindian, Saharo-Arabian and Arabian) and steppe (Irano-Turanian) elements. Palaeotropical elements (Afrotropical and Oriental) generally comprise about 10% distributed among various groups of animals (e.g., Bytinski-Salz (1954), Freidberg (1988), Furth (1975), Kugler (1988), Yom-Tov (1988)).

Following is a brief summary of the study of the weevil fauna of Israel. First works on the Israeli weevil fauna were either descriptions of new species (e.g., Desbrochers 1874–1875, 1897, Reiche and Saulcy 1855–1858, Reitter 1889, 1890), part of them in the revisions of large taxa (e.g., Bedel 1874, Petri 1901), or short lists resulting from collecting expeditions (e.g. Baudi 1894). Bodenheimer (1937) listed 219 weevil species in his "Prodromus", producing a very useful, but also partly erroneous and confusing list. Many species names were probably copied by Bodenheimer from Winkler's Catalogue (1924–1932). The Apionidae and the genus *Sitona* (Curculionidae) associated with cultivated legumes were studied by Melamed-Madjar (1966, 1969), who added several species to Bodenheimer's list. Gerling and Kugler (1973) recorded 31 species of weevils as natural enemies of certain noxious weeds. Halperin and Fremuth (2003) published a list of 135 weevil species from Halperin's private collection, which included mainly species reared from their host plants in the 1950–1990s and added ca. 90 species to the Israeli fauna. Pelletier (1999, 2003, 2006), Borovec (2003) and Borovec and Magnano (2004) revised several East Mediterranean genera of Entiminae, and Caldara (2008 a,b) revised the Levantine erirhinid genus *Picia* and the Palaearctic curculionid genus *Gymnetron*, respectively, documenting their diversity and adding new species to the Israeli fauna. My own studies of the weevil fauna of Israel began in 1996, and have so far resulted in recently published reviews of three weevil families: Apionidae (Friedman and Freidberg 2007), Rhynchitidae, and Attelabidae (Legalov and Friedman 2007), and records of two invasive species of Curculionidae (Friedman 2006, 2009).

Materials and methods

My studies are based mostly on specimens from the National Collection of Insects, Department of Zoology, Tel Aviv University, Israel (TAU). The TAU collection incorporates the results of the collecting efforts of several generations of Israeli entomologists over nearly 100 years, starting with the pioneers of Israeli entomology, the late I. Aharoni, F. S. Bodenheimer, H. Bytinski-Salz, O. Theodor and J. Kugler, as well as of those numerous, more recent collectors. Halperin's private collection was also incorporated into TAU. In addition, I have studied the collection of the Plant Protection and

Inspection Services, Ministry of Agriculture, Bet Dagan, Israel, and the private collection of Mr. E. Orbach, Qiryat Tiv'on, Israel. Numerous methods of collecting were used, including sweeping, beating, gathering, trapping by light traps and pitfall traps and rearing from host plants. Zoogeographical terminology follows Yom-Tov (1988).

Results

Biodiversity

Currently, about 600 weevil species are deposited at TAU and the number keeps growing. Based on the current rate of new species discovery, I estimate that the actual number of species in Israel will reach about 1.000. The families are listed in alphabetical order.

The **Anthribidae** contain predominantly xylophagous and mycetophagous species, mainly tropical, but with many species in the temperate regions. It is represented in Israel by two subfamilies: Anthribinae and Urodontinae. The Anthribinae are currently studied by B. Valentine (Ohio, USA) and myself, and we have so far recorded 11 species, most of which are Palaearctic. Three species are widely distributed in the Palaearctic Region, two are East Mediterranean, and two are known only from Lebanon and Israel (Upper Galilee). One is a cosmopolitan pest of stored food (*Araecerus fasciculatus* (DeGeer)). Two species of the Afrotropical genus *Cylindroides*, which are apparently undescribed, occur in the Rift Valley and in the Central and Southern Negev, and are probably associated with *Acacia*. The Urodontinae remain unstudied; although only two *Bruchela* species and one *Cercomorphus* species were recorded by Bodenheimer (1937), about 11 species of these genera are deposited at TAU.

The **Apionidae** comprise about 2.000 described species and about the same number of undescribed species worldwide, with 500–550 species in the Palaearctic region (Wanat 2001). The Israeli fauna is clearly Palaearctic. Friedman and Freidberg (2007) recorded 30 genera with 75 species in Israel, of which one genus and five species were described as new. Twenty-five genera have a wide Palaearctic distribution, three genera are circum-Mediterranean, one is Saharo-Sindian, and one is East Mediterranean. Forty species are more or less widely distributed over the western part of the Palaearctic region or in Europe and the Mediterranean region, one species is circum-Mediterranean, and 15 species are restricted to the East Mediterranean. Nine species are Levantine endemics (although seven of them are known only from Israel, there is no doubt that they also occur in neighboring countries). Six species are Saharo-Sindian. No Irano-Turanian or Afrotropical elements are known, however *Necatapion bruleriei* (Desbrochers), which is distributed across the East Mediterranean and is not related to any of the Palaearctic apionid groups, may represent a link to the Afrotropical fauna. Three species were not identified to species rank. I estimate that the number of apionids in Israel will eventually reach 80–90 species, as more species are likely to be found. One species of *Perapion* collected in the Upper Galilee was overlooked during the survey and apparently represents a new species. One, probably

alien, species was found in stored fruit originating from Israel (B. Korotyaev, pers. com.), and several of the species recorded from Jordan (Voss 1964, K. Schön, pers. com.) are likely to be found there.

The **Attelabidae** is a predominantly tropical family of leaf-rolling weevils (about 1.000 species), which is scarcely represented in the western part of the Palaearctic region by eight species (Legalov 2003). Its only representative that was recorded from Israel is *Attelabus nitens* (Scopoli) (Legalov and Friedman 2007). This species is associated with various species of oaks (in Israel predominantly with *Quercus boissieri* Reuter), and is widely distributed in the West Palaearctic region. It occurs only in the northernmost part of Israel, predominantly at high altitudes (Mt. Hermon, Mt. Meron, northern part of the Golan Heights), which apparently constitute the southern border of its distribution.

The **Brachyceridae** is represented in the Palaearctic region by the single genus *Brachycerus*. *Brachycerus* comprises nine species in Israel, of which two are apparently new to science and the rest are restricted to the Levant or to the East Mediterranean (Fig. 1A). This genus comprises about 500 species that are restricted to the Old World; about 250 species are found only in South Africa (mainly in the Cape Province), while the remainder inhabit other parts of the African continent, with less diversity towards the north (Haaf 1957a, b, 1958). About 50 closely related species occur in the Mediterranean, with some extensions into southern and eastern Europe and Central Asia (Arzanov 2005, Zumpt 1937a,b). It is unknown whether the Mediterranean fauna of *Brachycerus* represents a relict of the ancient epoch, or an invasion from the African continent into Eurasia. If the latter is correct, then Israel is on the route of such invasion, which can explain the relative species richness of *Brachycerus* in the Israeli fauna. A review of the *Brachycerus* species of Israel is currently in preparation by A. Sagiv and myself.

The **Brentidae** are predominantly tropical, with 1.754 species occurring south of 30° latitude, and only 42 species north of it (Sforzi and Bartolozzi 2004). Although only two species were recorded by Bodenheimer (1937) from Israel, the Brentidae fauna of Israel is probably the richest among the West Palaearctic countries. It comprises about 5–6 Mediterranean, Saharo-Sindian and Palaeotropical species, which predominantly belong to Afrotropical and Oriental genera. A review of the Brentidae of Israel is currently in preparation (E. Orbach, pers. com.).

The **Curculionidae** constitute the largest weevil family, of which at least 50,000 species have been described to date, and many still await description. Probably 500–600 species occur in Israel, of which ca. 450 are deposited at TAU. Following is a review of the 14 subfamilies of Curculionidae that are currently known from Israel, of which only some have been studied satisfactorily, and therefore data pertaining to them are summarized here generally.

Subfamily Bagoinae: includes at least five species of the genus *Bagous*, all of which are associated with aquatic biotopes (material partly studied by B. Korotyaev, ZIN, St. Petersburg, Russia).

Subfamily Baridinae: includes 22 species, of which two are new to science, both endemic to Mt. Hermon. Three species are East Mediterranean, one – circum-Medi-

terranean, four – West Palaearctic and two are widely distributed throughout the Palaearctic region. Six species (above 25%) are Saharo-Sindian, occurring predominantly in the Negev, Judean Desert and the 'Arava Valley, and most of them are associated with plants of the family Chenopodiaceae. *Baris memnonia* Boheman apparently represents

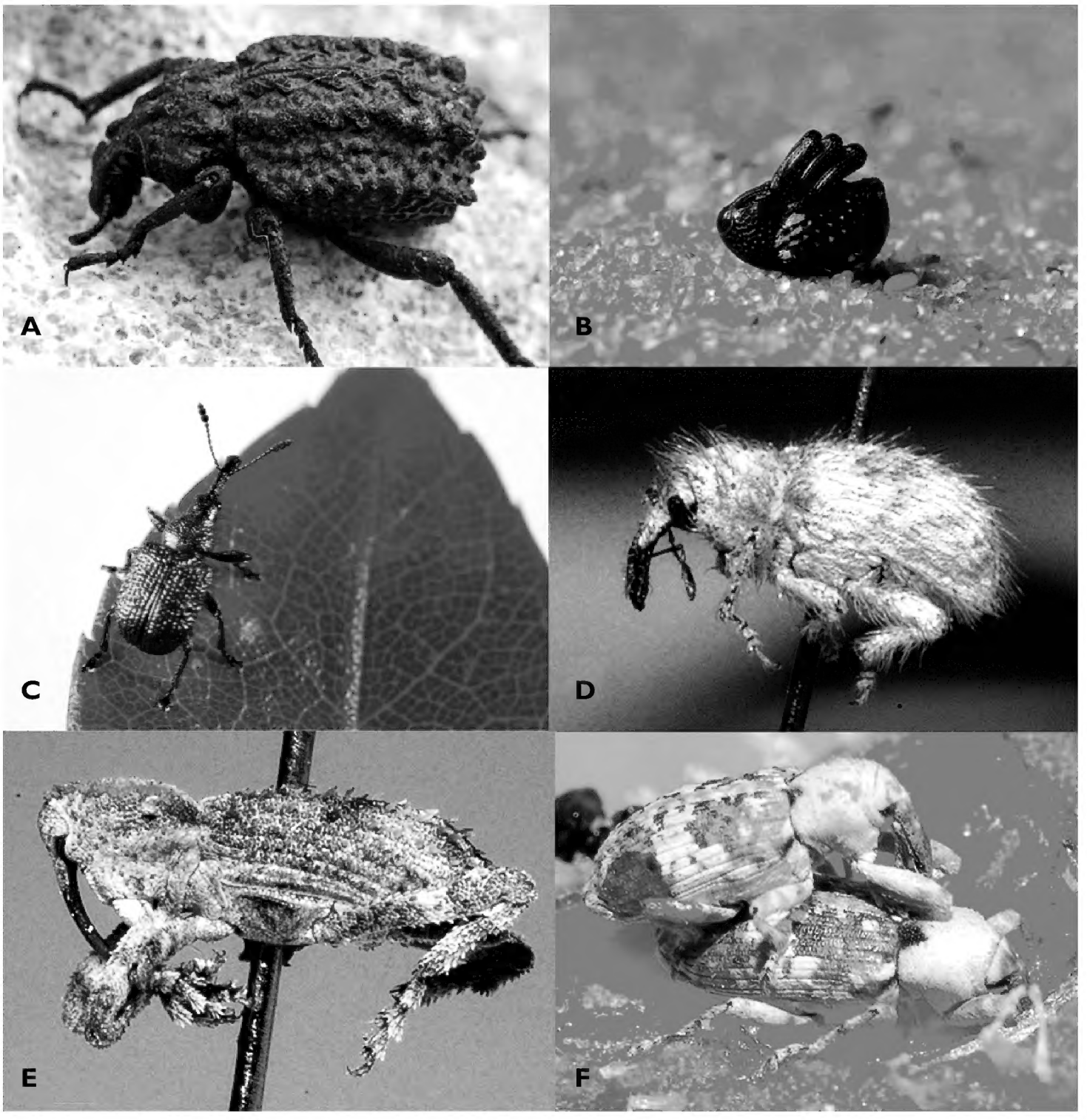

Figure 1. A *Brachycerus argillaceus* Reiche (Brachyceridae), an East-Mediterranean element, abundant in the Mediterranean zone of Israel (photo A. Nir) **B** *Ocladius paucisquamis* Meregalli and Colonnelli (Brachyceridae), an endemic of Israel and Jordan, inhabiting the Negev and 'Arava Valley, posing as if dead (photo G. Wizen) **C** *Rhynchites bacchus* (Linnaeus) (Rhynchitidae), a widely-distributed Palaearctic species, occurring in Israel only above 1.600 m a.s.l. on Mt. Hermon (photo A. Shoob) **D** *Trichocaulus longipilis* Fairmaire (Erirhinidae), a Saharo-Sindian element. The single specimen was collected near the Dead Sea; recorded for the first time from the East Mediterranean (photo O. Rittner) **E** *Camptorhinus erectisquamis* Marshall (Curculionidae: Cryptorhynchidae), an Afrotropical element, 'Arava Valley (photo O. Rittner) **F** *Acentrus histrio* (Schoenherr) (Curculionidae) in copula on *Glaucium oxylobum* (Papaveraceae) at 1.800 m a.s.l., on Mt. Hermon, recorded for the first time from the Levant (photo O. Rittner).

an Irano-Turanian element, whereas *Acythopeus curvirostris granulipennis* (Tournier) is the Middle Eastern member of an Afrotropical genus; both species occur in xeric biotopes. The affinities of the two species are unclear to me. A review of the Baridinae of Israel is currently under a preparation by B. Korotyaev and myself.

Subfamily Ceutorhynchinae: is recorded from Israel by 42 species (Colonnelli 2004), whereas it comprises above 60 species overall, nearly half of which in the widely distributed, nearly cosmopolitan genus *Ceutorhynchus*. The Israeli Ceutorhynchinae fauna is represented by local endemic and Saharo-Sindian species, and by species widely distributed in the Western Palaearctic, although East Mediterranean elements are prevalent (30–40%). Part of the material at TAU has been studied by B. Korotyaev, but the work is still incomplete.

Subfamily Conoderinae: is represented in Israel by *Coryssomerus capucinus* Beck, which is widely distributed in the Palaearctic Region, and particularly in the Mediterranean area, as well as by the Afrotropical *Sphadasmus maculatus* Hustache, which is associated with *Acacia* in the 'Arava Valley.

Subfamily Cossoninae: includes eight species in seven genera, of which six were recorded by Halperin and Fremuth (2003). One species is West Palaearctic, three are Mediterranean, and three are cosmopolitan (two stored-food pests and the coast-dwelling *Pselactus spadix* (Herbst), which is associated with timbers floating in marine water). One species which is known from a single specimen is still undetermined; it was collected in the Jordan Valley and is currently under study by N. Maughan (Aix en Provence, France).

Subfamily Cryptorhynchinae: comprises eight species in six genera. Four species are endemic to Israel (but apparently have a wider distribution in the Levant), with one species new to science. One is Mediterranean, and two are East Mediterranean. *Camptorrhinus erectisquamis* Marshall (Fig. 1E), which is found in the 'Arava Valley and is associated with *Acacia*, constitutes an Afrotropical element. It occurs along the Rift Valley from Israel in the north to Zambia in the south. The relevant TAU collection was identified by P. Stüben and F. Bahr (Curculio-Institut, Mönchengladbach, Germany).

Subfamily Curculioninae: is the largest and the least studied group of Curculionidae in Israel. Although recorded from Israel by 30–60 species (Bodenheimer 1937, Halperin and Fremuth 2003), it apparently includes more than 130 species in 20–30 genera, of which *Sibinia* and *Tychius* are probably the most species rich, with about 20 species each. The East-Mediterranean species dominate among the Palaearctic elements (within the genera *Anthonomus*, *Curculio*, *Cionus*, *Mecinus*, *Rhinusa*, *Sibinia*, *Smicronyx*, *Tychius* etc.). Saharo-Sindian elements have a considerable representation (particularly in the genera *Geranorhinus*, *Sharpia*, *Sibinia*), whereas the widely-distributed Palaearctic species are restricted predominantly to high altitudes (e.g. *Cionus scrophulariae* (Linnaeus) on Mt. Hermon and the Golan Heights). The Afrotropical element is represented by species that are associated with Afrotropical vegetation (e.g. *Acacia*, *Ziziphus*) and found in the Negev and the Rift Valley (e.g. *Bradybibastes discoidalis* (Tournier), *Sphincticraerus* spp., *Rhamphus kiesenwetteri* Tournier). *Derelomus pifriformis* Hoffmann, previously a Canary Islands endemic, invaded the Mediterra-

nean area at the beginning of the twentieth century and in recent years has been found as far east as Israel (Friedman 2006).

Subfamily Cyclominae: only two species were recorded in Israel (Bodenheimer 1937). Although this subfamily is represented by three species of *Borborocoetes* and two species of *Gronops*, all are undetermined and therefore their zoogeographical affinities are unclear; and an invasive Neotropical species, *Listroderes costirostris* Schoenherr (Friedman 2009).

Subfamily Entiminae: previously recorded by Halperin and Fremuth (2003) and by Bodenheimer (1937) as containing 18 and 37 species, respectively. However, this subfamily is represented at TAU by at least 78 species in 27 genera, with about a dozen species and at least two genera that are new to science. This group seems to exhibit the highest rate of endemism within the Curculionidae: 31 species (~40%) are endemic to the East Mediterranean, 17 (~22%) are endemic to Israel (or to the Levant), six species are Saharo-Sindian, 14 are Mediterranean, and eight have a fairly wide Palaearctic distribution. Eight genera are restricted to the East Mediterranean, and one is known so far only from Israel. Although several genera have a wider distribution in the Mediterranean or the Palaearctic regions, they are still mainly found in the East Mediterranean (e.g. *Strophomorphus*). The widely distributed Palaearctic genus, *Otiorhynchus*, comprises dozens of species in any West Palaearctic country. This genus is represented in Israel by only five species, two of which are restricted to Mt. Hermon and the Golan Heights and the rest to the other high-altitude regions of the Mediterranean zone. Three genera are Saharo-Sindian elements. The Palaeotropic genus *Myllocerus* is represented by an undetermined desert species. The Entiminae of Israel are currently studied by R. Borovec (Sloupno, Czech Republic), J. Pelletier (Monnaie, France), A. Velazques de Castro (Valencia, Spain) and myself.

Subfamily Hyperinae: previously recorded by Halperin and Fremuth (2003) and by Bodenheimer (1937) as having 7 or 19 species in Israel, respectively. However, this subfamily comprises at TAU ca. 30 species in Israel, including several agricultural pests. About one third of these species are Saharo-Sindian and the rest are Mediterranean or West Palaearctic. The Hyperinae at TAU are currently being studied by H. Winkelmann (Berlin, Germany).

Subfamily Lixinae: previously recorded by Halperin and Fremuth (2003) and by Bodenheimer (1937) as having 22 and 59 Israeli species, respectively. However, this subfamily probably contains more than 100 species in Israel, based on an ongoing study by F. Talamelli (San Giovanni in Marignano, Italy) and myself. While the Cleonini and Larinini have been studied to some extent, the Lixini remain completely unstudied. Most of the species in this genus are Palaearctic, with at least one third being Saharo-Sindian, and several Afrotropical species.

Subfamily Mesoptiliinae: is represented at TAU by a single specimen of an undetermined *Magdalis* species which was collected on Mt. Hermon, at 1.600 m. The Palaearctic *Magdalis linearis* (Gyllenhal) was recorded in Israel by Klein and Chen (1983) as an invasive pest of *Pinus*, but no specimens or damage have been reported since.

Subfamily Molytinae: was previously recorded by Osella (1985) to have a single species in Israel, but five more species are deposited in the TAU collection, three of which are Palaearctic elements. For the widely-distributed Palaearctic *Myniops carinatus* (Linnaeus) Israel (Upper Galilee) is the southernmost record. Two species are East Mediterranean: *Pseudanchonidium galilaeum* Osella from the Upper Galilee (Osella 1985) and *Liparus* (*Trysibius*) sp., represented by a single specimen from Mt. Hermon, 1.600 m above sea level. Afrotropical elements included in this subfamily are *Aorus anthracinus* Brancsik, which used to occur in the Hula Valley, but became extinct after drainage of the Hula Lake in the 1950s, and *Paramecops sinaitus* Pic that is found in the Central and Southern Negev. One ground-dwelling species occurring in the Central Negev remains undetermined to genus level, and its zoogeographical status is unclear.

Subfamily Ocladiinae: is represented in Israel by a single species *Ocladius paucisquamis* Meregalli and Colonnelli (Fig. 1B), which is found in the southern part of Israel (Negev and 'Arava Valley). The genus *Ocladius* Schoenherr is widely distributed in xeric habitats of the Afrotropical region, the Mediterranean basin and Central Asia (Meregalli and Colonnelli 2006).

The **Dryophthoridae** include mostly tropical species that are associated with monocots. In Israel, this family is represented by seven species, two of which are well-known stored-food pests (the rice weevil, *Sitophilus oryzae* (Linnaeus), and the corn weevil, *S. zeamais* Motschulsky) of cosmopolitan distribution and unknown origin. Two species are invasive pests (the circum-Tropical red palm weevil, *Rhynchophorus ferrugineus* (Olivier), and the Neotropical *Sphenophorus* sp.). Another species, *Sphenophorus parumpunctatus* (Gyllenhal), is circum-Mediterranean. The granary weevil, *Sitophilus granarius* (Linnaeus), which was common in Israel in the past, disappeared from the country around the 9th century CE (Kislev and Simchoni 2007). It has repeatedly been introduced from Europe in imported goods in recent times, but is probably unable to complete its life cycle (Rivnay 1962). An unidentified species of *Sitophilus*, which is similar to but significantly larger than *S. granarius*, was collected recently in the Upper Galilee, in rotting foliage of the Mediterranean maquis. It is noteworthy that the nearly cosmopolitan xylophagous genus *Dryophthorus*, which is found both in the tropics and in temperate regions and is distributed widely in the Palaearctic Region, is completely absent from Israel.

The **Erirhinidae** were previously recorded from Israel only for the widespread Palaearctic genus *Procas*, by the Levantine subspecies *P. picipes levantinus* Thompson (Bodenheimer 1937, Thompson 2006). So far, it is known from a single specimen that was collected on a light trap in the Judean Foothils (Ben Shemen Forest) (Bodenheimer 1932). The TAU collection includes five additional erirhinid species. Three of these species are rare desert weevils: *Trichocaulus longipilis* Fairmaire (Fig. 1D), known previously only from Algeria and Tunisia, *Arthrostenus fullo* Boheman, and *Theanellus* sp. The latter two species apparently represent an Irano-Turanian element. Two species are associated with aquatic habitats: the Levantine endemic *Picia syriaca* (Reitter) and *Icaris sparganii* (Gyllenhal), distributed widely throughout both Palaearctic and Afrotropic regions.

The **Nanophyidae** probably constitute one of the least studied weevil families worldwide. The body length of the Palaearctic Nanophyidae usually does not exceed 1.5–2 mm, and therefore they are seldom collected and their small size and high morphological diversity hamper taxonomic study. The Nanophyidae probably comprise about 200 species, predominantly in the Old World tropics and the Palearctic region. Nine species were recorded from Israel (Bodenheimer 1937, Giordani-Soika 1937, Halperin and Fremuth 2003). I am currently working on the Israeli fauna and estimate their number at 15 species, with two undescribed species. The Palaearctic Nanophyidae are divided into two distinct subfamilies: the Corimaliinae and Nanophyinae. The Corimaliinae are associated with Tamaricaceae and are of Saharo-Sindian origin. In Israel they are represented by eight species, all from *Tamarix*. The Nanophyinae are associated with Lythraceae, Crassulaceae and Ericaceae, and in Israel include seven East Mediterranean or Levantine species, six of which are associated with *Lythrum salicaria* L. (Lythraceae).

The **Nemonychidae** is considered a primitive family of predominantly pollenophagous weevils, occurring in the Holarctic region, Australia, New Zealand and South America. To date, only *Nemonyx lepturoides* (Fabricius) has been recorded from the Middle East (Lebanon) (Kuschel 1993). Two specimens recently obtained extend the distribution of this family in the Middle East further south. The first was collected in Israel and probably represents a new species of *Cimberis*. The second was collected in Jordan and although it resembles the Algerian *Nemonyx semirufus* Pic, it is apparently a new species which probably occurs also in Israel.

The **Rhynchitidae** include about 1.100 species. They are species-rich in the tropics, especially in the Palaeotropic Region, and are represented in the western part of the Palaearctic Region by 60–70 species in 26 genera (Legalov 2003). In Israel, the Rhynchitidae are represented only by West-Palaearctic genera, with 14 species, of which five are East Mediterranean and two are local endemics. These were recently described from Israel, although at least one of them also occurs in Syria (J. Pelletier, pers. com.), whereas the rest have a more or less wide distribution in the Palaearctic region. Four of the 14 species occur only on Mt. Hermon, three of them only above 1.600 m (Fig. 1C). The rest are found mostly in northern Israel that features a Mediterranean climate, and predominantly at high altitudes (Mt. Hermon, Golan Heights, Upper Galilee and Carmel Ridge). Only three species occur as low as the northern Coastal Plain, and as far south as Samaria and the Judean Hills. For all these species Israel is apparently the southernmost limit of their distribution (Legalov and Friedman 2007).

Zoogeography

Although research into the taxonomy and zoogeography of the weevils of Israel is still very much in its infancy, some general conclusions can already be drawn (Table 1). Israel's weevil fauna is predominantly of Palaearctic origin; most genera have a wide

Table 1. Zoogeographical affinities within the weevil fauna of Israel, expressed as percentages out of the total number of species in each group. Note: the less studied groups (Anthribidae (Urodntinae), Brentidae and 11 subfamilies of Curculionidae) were not included in the analysis).

								Curculionidae			
	Apionidae	**Nanophyidae**	**Brachyceridae**	**Attelabidae**	**Rhynchitidae**	**Dryophthoridae**	**Erirhinidae**	**Baridinae**	**Cryptorhynchinae**	**Entiminae**	**Anthribidae (Anthribinae)**
Cosmopolitan						42.8					
Palaearctic + Afrotropical							16.7				
Holarctic	1.3									2.6	
Palaearctic:	92.2	100.0	100.0	100.0	100.0	28.6	83.3	86.5	87.5	94.9	100
Wide Palaearctic	7.8			100.0	50.0			9.1		7.7	36.3
West Palaearctic	44.1							18.2			
Mediterranean	1.3					14.3		4.5	12.5	17.9	
East Mediterranean	19.5	46.7	70.0		35.7			13.6	25.0	39.7	18.2
Saharo-Sindian	7.8	53.3	30.0				16.7	27.3		7.7	
Irano-Turanian							33.3	4.5			
Levantine endemic	11.7				14.3	14.3	33.3	9.1	50.0	21.8	18.2
Afrotropical	1.3?							4.5	12.5	1.3	18.2
Invasive	1.3					28.6				1.3	9.1
unclear	3.9							9.2			
Total number of species	*77*	*15*	*10*	*1*	*14*	*7*	*6*	*22*	*8*	*~78*	*11*

Palaearctic distribution, although at least one third of the species are restricted to the Middle East. Endemism rates are high, particularly in flightless groups (e. g. Brachyceridae, Entiminae).

The Saharo-Sindian (desert) elements in most groups constitute no more than 10–20%, which is apparently a collection bias caused by insufficient collecting in the desert regions of Israel. Experience over recent years has shown that many species still remain to be collected. Many desert elements are associated with coastal dunes and the sands of the Northern Negev and the 'Arava Valley.

The Irano-Turanian (steppe) elements are weakly represented in the weevil fauna of Israel, probably because there are no real steppes in Israel, but rather semi-deserts with a considerable steppe element. It is most likely that the percentage of Irano-Turanian elements will "increase" following more detailed studies.

The Palaeotropical element is represented by at least 20 species, mostly of Afrotropical origin, but belonging to widespread Palaeotropical genera. These are primarily found in the Rift Valley, and many are associated with Afrotropical vegetation (e.g. *Acacia*, *Ziziphus*). To date, no distinct Oriental elements have been reported for the Israeli weevil fauna.

Israel's weevil fauna includes approximately five species of Holarctic distribution and four cosmopolitan species (three of which are stored-food pests). Nine invasive species have been found in Israel so far: three of them Neotropical (*Naupactus cervinus* Boheman, *Listroderes costirostris* Schoenherr and *Sphenophorus* sp.); four Afrotropical (*Rhynchophorus ferrugineus* (Olivier), *Pseudomimus avocado* Folwaczny, the almost cosmopolitan *Araecerus fasciculatus* (DeGeer), and an undetermined apionid); the cosmopolitan *Caulophilus oryzae* (Gyllenhal); and *Derelomus piriformis* Hoffmann, previously endemic to the Canary Islands and now widespread in the Mediterranean.

For many species of weevils, Israel is the border of their distribution. It is the southern border for the temperate Palaearctic species, many of which occur only at high altitudes on Mt. Hermon and the adjacent northern part of the Golan Heights, the Upper Galilee (particularly Mt. Meron), the Carmel Ridge and the western slopes of the Judean Hills. At the same time Israel constitutes a northern border for the Saharo-Sindian and Afrotropical species, particularly in the Negev Desert, the Dead Sea area and the 'Arava Valley.

Acknowlegments

I cordially thank my colleagues and friends Yu. Arzanov, F. Bahr, R. Borovec, R. Caldara, V. Chikatunov, E. Colonnelli, J. Fremuth, J. Halperin, M. Kislev, B. Korotyaev, A. Legalov, M. Meregalli, N. Maughan, E. Orbach, J. Pelletier, G. Sabatinnelli, K. Schön, P. Stüben, F. Talamelli, B. Valentine, A. Velázques de Castro, M. Wanat , H. Winkelmann, D. Wraze and S. Ziani for their kind help of many kinds, and particularly E. Neubert, V. Kravchenko, S. Zonstein and the anonymous reviewers for their useful comments on the manuscript. I am especially indebted to Netta Dorchin, A. Freidberg, and Naomi Paz for editing earlier drafts of the manuscript, and to O. Rittner, A. Nir and G. Wizen, who kindly allowed me to use their photographs.

References

Alfieri A (1976) The Coleoptera of Egypt. Mémoires de la Société Entomologique d'Egypte 5. Atlas Press, Cairo. 362 pp.

Alonso-Zarazaga MA, Lyal CHC (1999) A World catalogue of families of Curculionoidea (Insecta: Coleoptera) (Excepting Scolytidae and Platypodidae). Entomopraxis, S. C. P. Edition, Barcelona, Spain. 315 pp.

Alonso-Zarazaga MA, Lyal CHC (2002) Addenda and corrigenda to "A World Catalogue of Families and Genera of Curculionoidea (Insecta: Coleoptera)". Zootaxa, 63:1–37.

Alziar G (2007) The Curculionoidea-Fauna of Cyprus. Le Charançon: Catalogues & Keys, No. 3. CURCULIO-Institute, Mönchengladbach. http://www.curci.de/illustrated_catalogue/curculionoidea-fauna_of_cyprus/

Baudi F (1894) Viaggio del Dr E. Festa in Palestina, nel Libano e regioni vicine. Bollettino dei Musei di Zoologia ed Anatomia comparata della R. Università di Torino 9 (173): 1–13.

Bedel L (1874) Révision des Brachycérides du bassin de la méditerranée. Annales de la société entomologique de France 5 (4): 119–211, + 1pl.

Bodenheimer FS (1932) Studies on the ecology of Palestinean Coleoptera. I. Coleoptera at light traps. Bulletin de la Société Royale Entomologique d'Egypte 1–2: 52–65.

Bodenheimer FS (1937) Prodromus Faunæ Palestinæ. Mémoires de l'Institut d'Égypte 32. 286 pp.

Borovec R (2003) Revision of genera *Gyratogaster*, *Leianisorhynchus* and *Altonomus* (Coleoptera: Curculionidae: Entiminae: Cyphicerini). Klapalekiana 39: 1–30.

Borovec R, Magnano L (2004) Two new species of Phyllobiini from Syria, Turkey, Lebanon and Israel (Coleoptera: Curculionidae: Entiminae: Phyllobiini). Snudebiller 5: 6–24.

Borumand H (1998) Insects of Iran. The list of Coleoptera in the insect collection of Plant Pests and Diseases Research Institute. Ministry of Agriculture, Agricultural Research, Education and Extention Organisation. Plant Pests and Deseases Research Institute. Insect Taxonomy Research Department, Publ. No.2. 116 pp.

Bytinski-Salz H (1954) Insects associated with desert acacias in Israel. Bulletin of the Research Council of Israel 4 (3): 284–292.

Caldara R (2008a) A taxonomic revision of the weevil genus *Picia* Tournier, 1895 (Coleoptera: Curculionoidea: Erirhinidae). Zootaxa 1959: 39–57.

Caldara R (2008b) Revisione delle specie Paleartiche del genere *Gymnetron* (Insecta, Coleoptera: Curculionidae). Aldrovandia 4: 27–103.

Colonnelli E (1984) Insects of Saudi Arabia. Coleoptera: Fam. Curculionidae Ceutorhynchinae. Fauna of Saudi Arabia 6: 367–375.

Colonnelli E (1987) Ceutorhynchinae raccolti in Giordania da J. Klapperich (Coleoptera, Curculionidae). Fragmenta Entomologica, 19(2): 363–369.

Colonnelli E (2004) Catalogue of Ceutorhynchinae of the world with a key to genera (Insecta: Coleoptera: Curculionidae). Argania edition. Barcelona. 124 pp.

Desbrochers J (1874–1875) Opuscules Entomologiques (Coléoptères). Ier Cahier: 1–37.

Desbrochers J (1897) Premier Supplement à la monographie des Apionides. Le Frelon 6: 1–53.

Freidberg A (1988) Zoogeography of Diptera in Israel. pp. 251–276. In: Yom-Tov Y, Tchernov E. (Eds). The zoogeography of Israel. Dr. W. Junk Publishers, Dodrecht. 600 pp.

Friedman ALL (2006) *Derelomus piriformis* Hoffmann (Curculionoidea: Curculionidae: Curculioninae: Derelomini), a new invasive species in Israel. Phytoparasitica 34, 357–359.

Friedman ALL (2009) The vegetable weevil, *Listroderes costirostris* Schoenherr (Curculionidae: Cyclominae): a new invasive pest in Israel. Phytoparasitica 37 (4): 331–332.

Friedman ALL, Freidberg A (2007) The Apionidae of Israel and the Sinai Peninsula (Coleoptera: Curculionoidea). Israel Journal of Entomology 37: 55–180.

Furth DC (1975) Israel, a great biogeographic crossroads. Discovery (Peabody Museum) 11(1): 2–13.

Gerling D, Kugler J (1973) Evaluation of enemies of noxious plants in Israel as potential agents for the biological control of weeds, Tel Aviv University, George S. Wise Center for Life Sciences, Department of Zoology. Tel Aviv, Israel.

Giordani-Soika A (1937) Risultati scientifici delle spedizioni entomologiche di S.A.S. il Principe Alessandro della Torre e Tasso nel bacino del Mediterraneo. I° Le specie mediterranee del genere *Corimalia* (Col., Curcul.). Pubblicazioni del Museo Entomologico "Pietro Rossi" Duino 2:1–29 + 2 pl.

Haaf E (1957a) Revision der äthiopischen und madagassischen Arten der Gattung *Brachycerus* Ol. (Col. Curc.) (Mit 70 Textabbildungen). Entomologiche Arbeiten aus dem Museum G. Frey 8(1): 1–274.

Haaf E (1957b) Revision der äthiopischen und madagassischen Arten der Gattung *Brachycerus* Ol. (Col. Curc.) (Mit 70 Textabbildungen). (Fortsetzung). Entomologiche Arbeiten aus dem Museum G. Frey 8(2): 343–560.

Haaf E (1958) Neue äthiopische *Brachycerus*-Arten und eine neue Gattung der Subfamilie Brachycerinae (Col. Curc.). Entomologiche Arbeiten aus dem Museum G. Frey 9: 220–228.

Halperin J, Fremuth J (2003) Contribution to the knowledge of Curculionoidea (Coleoptera) and their host plants in Israel. Zoology in the Middle East 29: 93–100.

Katbeh-Bader A (2002) Contribution to the Curculionudae (Coleoptera) of Jordan. Zoology in the Middle East 25: 71–78.

Klein ZI, Chen Ch (1983) Interception and introduction of new pests in Israel. Phytoparasitica, 11: 124–125.

Kislev M, Simchoni O (2007) Hygiene and insect damage of crops and foods at Masada. Pp. 133–170. In: Masada VIII. The Yigael Yadin Excavations 1963–1965. Final Reports. Israel Exploration Society. The Hebrew University of Jerusalem. Jerusalem.

Kugler J (1988) The zoogeography of social insects of Israel and Sinai. pp. 251–276. *In* Yom-Tov Y, Tchernov E. (Eds). The Zoogeography of Israel. Dr. W. Junk Publishers, Dodrecht. 600 pp.

Kuschel G (1993) The Palaearctic Nemonychidae (Coleoptera: Curculionoidea) Annales de la Société entomologique de France 29(1): 23–46.

Legalov AA (2003) Taxanomy, classification and phylogeny of the leaf-rolling weevils (Coleoptera: Rhynchitidae, Attelabidae) of the world fauna. Novosibirsk. 733 pp. (CD-rom, 641 Mbytes) [in Russian]

Legalov AA, Friedman ALL (2007). Review of the leaf-rolling weevils of Israel (Coleoptera; Curculionoidea: Rhynchitidae and Attelabidae). Israel Journal of Entomology 37: 181–203.

Louw S Vdm (2004) Microcerini Lacordaire, 1863 (Coleoptera, Curculionodea) (pp. 905–936). In: Sforzi A, Bartolozzi L (Eds) (2004) Brentidae of the World (Coleoptera: Curculionoidea). Monografie XXXIX (39), Museo Regionale di Scienze Naturali, Torino, Italy. 976 pp.

Lyal CHC & Alonso-Zarazaga MA (2006) Addenda and corrigenda to "A World Catalogue of Families and Genera of Curculionoidea (Insecta: Coleoptera)" 2 Zootaxa 1202: 21–31.

Magnano L, Colonnelli E, Caldara R (2009) Order Coleoptera, superfamily Curculionoidea. Families Anthribidae, Brentidae, Apionidae, Nanophyidae, Curculionidae and Dryophthoridae. Arthropod fauna of the UAE, 2: 216–266.

Melamed-Madjar V (1966) The phenology of *Sitona* (Coleoptera, Curculionidae) in Israel. Israel Journal of Entomology 1: 63–74.

Melamed-Madjar V (1969) Studies on the phenology of three species of *Apion* (Col.: Curculionidae), occuring on winter leguminose crops in Israel. Israel Journal of Entomology 4: 97–105.

Meregalli M, Colonnelli E (2006) The genus *Ocladius* Schönherr 1825 in the Arabian subregion, with description of six new species (Coleoptera: Curculionoidea: Curculionidae). Fauna of Saudi Arabia 21: 251–306.

Oberprieler RG, Marvaldi AE, Anderson RS (2007) Weevils, weevils, weevils everywhere. Zootaxa 1668: 491–520. In: Zhang Z-Q and Shear WA (Eds) (2007) Linnaeus tricentenary: Progress in Invertebrate Taxonomy. Zootaxa, 1668: 1–766.

Osella G (1985) Un nuovo *Pseudoanchonidium* Osella d'Israele (Col. Curc.: Hylobiinae). Revue Suisse de Zoologie 92 (1): 89–92.

Pelletier J (1999) Révision du genre *Strophomorphus* Seidlitz, 1867 (Coleoptera, Curculionidae). Zoosystema 21 (4): 681–750.

Pelletier J (2003) Révision du genre *Achradidius* Kiesenwetter, 1864 (Coleoptera, Curculionidae) Bulletin de la Société entomologique de France 108 (1): 35–48.

Pelletier J (2006) Révision du genre *Eptacus* Desbrochers, 1908 (Coleoptera, Curculionidae, Entiminae). Bulletin de la Société entomologique de France 111 (2): 207–221

Petri K (1901) Monographie des Coleopteren – Tribus Hyperini. R. Friedländer & Sohn, Berlin, 210 pp.

Reiche L, de Saulcy F (1855–1858) Coléoptères Novuveax ou Peu Connus, recueillis par M. de Saulcy, Membre de l'Institut, dans son voyage en Grèce, en Palestine et autourde la Mer Morte de Décembre 1850 à Avril 1851. Extrait des Annales de la Société Enntomologique de France. Paris. 338 pp.

Reitter E (1889) Coleopterologische Ergebnisse der im Jahre 1886 und 1887 in Transcaspien von Dr. G. Radde, Dr. A. Walter und A. Konchin ausgeführten Expedition. Verhandlungen des naturforschenden Vereines in Brünn, 27 (1888): 95–133.

Reitter E (1890) Coleopterologische Notizen. XXXVII. Wiener Entomologische Zeitung, 142–146.

Rivnay E (1962) Field Crop Pests in the Near East. Monographiae Biologicae X. Dr. W. Junk, Den Haag, 450 pp.

Sforzi A, Bartolozzi L (2004) Brentidae Billberg, 1820 (Brentinae, Cyphagoginae, Pholdochlamydinae, Taphoderinae, Trachelizinae, Ulocerinae) (Coleoptera, Curculionoidea) (pp. 873–903). In: Sforzi A, Bartolozzi L (Eds) (2004) Brentidae of the World (Coleoptera: Curculionoidea). Monografie XXXIX (39), Museo Regionale di Scienze Naturali, Torino, Italy. 976 pp.

Thompson RT (2006) A revision of the weevil genus *Procas* Stephens (Coleoptera: Curculionoidea: Erirhinidae) Zootaxa 1234: 1–63.

Voss E (1964) Von J. Klapperich im Jordan-Gebiet gesammelte Rhynchiten und Apionen. (186. Beitrag zur Kenntnis der Curculioniden). Rovartani Közlemények. Folia Entomologica Hungarica (series nova) 17 (27): 385–393.

Wanat M (1990) Apionidae (Coleoptera: Curculionoidea) of the Arabian Peninsula. Fauna of Saudi Arabia 11: 55–81.

Wanat M (2001) Genera of Australo-Pacific Rhadinocybinae and Myrmacicelinae With Biogeography of the Apionidae (Coleoptera: Curculionoidea) and Phylogeny of the Brentidae (s. lato). Binding: Hardcover Publisher: Mantis Publishing, Olsztyn, 432 pp.

Winkler A (Ed) (1924–1932) Catalogus Coleopterorum Regionis Palearcticae. Wien. 1698 pp.

Yom-Tov Y (1988). The zoogeography of the birds and mammals of Israel. Pp. 389–410. In: Yom-Tov Y, Tchernov E (Eds) (1988). The zoogeography of Israel. Dr W. Junk Publishers, Dodrecht 600 pp.

Zumpt F (1937a) Curculioniden-Studien XXVII. Revision der paläarktischen *Brachycerus*-Arten (Mit 55 Abbildungen und 3 Karten). Entomologische Blätter, 33(5): 348–374.

Zumpt F (1937b) Curculioniden-Studien XXVII. Revision der paläarktischen *Brachycerus*-Arten (Mit 55 Abbildungen und 3 Karten) (Schluss). Entomologische Blätter, 33(6): 385–426.